EXHIBIT 2-7

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UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

IN RE FOREIGN EXCHANGE BENCHMARK RATES ANTITRUST LITIGATION	No. 1:13-cv-07789 (LGS)

Expert Report of Divya Mathur, Ph.D.

May 20, 2022

fixed effect for 2008 is equal to one between July 1, 2008 and June 30, 2009 (and zero otherwise), while the year fixed effect for 2009 is equal to one between July 1, 2009 and June 30, 2010 (and zero otherwise). The Class Period indicator is equal to one on or before December 31, 2013, and zero afterward.[197]

97. Focusing on the estimated coefficient on the "Conduct" indicator, Dr. Singer concluded that implied EBS half-spreads were 0.0041 percent wider in the interdealer segment during the Class Period as a result of the alleged conspiracy and infers from this result that Defendant banks charged similarly wider spreads in the customer segment as part of the alleged conspiracy.[198] However, as I explain below, (i) Dr. Singer's regression cannot identify the causal impact of the alleged conspiracy on spreads; and (ii) Dr. Singer's interpretation of his results is incorrect.

1. Dr. Singer's Regression Cannot Identify the Causal Effect of Any Alleged Collusion on Spreads

98. Dr. Singer's regression cannot measure the impact of the alleged conspiracy on EBS half-spreads. Because the alleged conspiracy is unobservable, Dr. Singer's regression analyzes the correlation between the *Class Period* and implied spreads.[199] His regression also

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[197] Singer Merits Report, ¶¶ 52 (pp. 37-39).

[198] Singer Merits Report, ¶ 55. Dr. Singer's model purports to show that, in the absence of the alleged conspiracy, the EBS bid price would have been 0.0041 percent higher and the EBS ask price would have been 0.0041 percent lower. Based on these results, Dr. Singer calculated that the spread would have been 0.0082 percent (= 0.0041 + 0.0041) narrower.

[199] Singer Merits Report, ¶¶ 49, 50 (pp. 36-37).

controlled for each year during the Class Period.[200] However, the Class Period is indistinguishable from these year controls, because the year controls and the Class Period are perfectly correlated during almost the entire period analyzed by Dr. Singer. As a result, Dr. Singer's regression can only determine whether implied spreads shift over time, but it cannot distinguish between shifts due to the alleged conspiracy and "shifts over time in market conditions" unrelated to the challenged conduct (*e.g.*, new entrants, new technology, more electronic trading, etc.).[201]

99. Specifically, Dr. Singer's regression included separate controls for consecutive (mutually-exclusive) 12-month-long periods covering the entire observed trading period (from December 1, 2007 to December 31, 2015) and a "Conduct" variable equal to one before December 31, 2013 and zero otherwise.[202, 203] This "Conduct" variable is meant to capture the effect of the challenged conduct on EBS half-spreads.[204] However, in almost all periods, Dr. Singer's "Conduct" variable and his time-period controls capture the same variation; *i.e.*, variation in implied EBS half-spreads over time. In every year before July 2013 (*i.e.,* during the Class Period), the "Conduct" variable is unchanged (equal to one). Therefore, these two variables

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200 Singer Merits Report, ¶ 51 (p. 37). The year controls are also called "time period fixed effects." Dr Singer says he included these time period fixed effects to help him control for "shifts over time in market conditions such as industry concentration and increased reliance on electronic execution methods." (Singer Merits Report, ¶ 54).

201 Singer Merits Report, ¶ 54.

202 Singer Merits Report, ¶ 51 (p. 37).

203 Dr. Singer considers two alternative "conduct periods" which end on November 30, 2013 and October 31, 2013, respectively. (Singer Merits Report, ¶ 55. Dr. Singer claims that these alternative conduct dates "confirm robustness of [his] results" (*Id*.).

204 Singer Merits Report, ¶ 51 (p. 37).

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(the "Conduct" variable and the time-period controls during the Class Period) capture the same effects. A regression analysis cannot yield reliable results if it controls for the same variable twice, as explained in the econometrics textbook cited by Dr. Singer himself.[205] In fact, the textbook cited by Dr. Singer describes the flaws in Dr. Singer's methodology and regression model based on in its treatment of multiple years of data and the "Conduct" variable:

> "When we include a full set of year dummies – that is, year dummies for all years but the first – we *cannot estimate* the effect of any variable whose change across time is constant."[206]

100. Only in one twelve-month period, from July 1, 2013 to June 30, 2014, is Dr. Singer's "Conduct" variable able to capture something other than shifts in half-spreads over time. Dr. Singer's year controls run from July 1 of a given year to June 30 of the following year, while his "Conduct" variable changes from one to zero on December 31, 2013.[207] Therefore, Dr. Singer's "Conduct" variable would only identify the average EBS half-spread difference between the last six months of the Class Period (July 1, 2013, through December 31, 2013) and the first six months immediately following the Class Period (January 1, 2014 through

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[205] Wooldridge, Jeffrey M., *Introductory Econometrics: A Modern Approach*, 5th Edition (2012), Cengage Learning ("Wooldridge"), p. 84: "If an independent variable [] is an exact linear combination of the other independent variables, then we say the model suffers from perfect collinearity, and *it cannot be estimated by OLS [regression]*" (emphasis added). A variable is a linear combination of another variable if it can be constructed by multiplying and/or adding a constant to the other variable (Wooldridge, p. 801). Therefore, the textbook confirms that Dr. Singer's regression cannot be estimated (except for one 12-month period), because the "conduct" variable is an exact linear combination of the year fixed effects in all but one 12-month period.

[206] Wooldridge, p. 487. Emphasis added. In this case, Dr. Singer included year controls (*i.e.*, dummies), and Dr. Singer's "conduct" variable is constant over time (except for in one 12-month period). Therefore, Dr. Singer's "conduct" variable does not measure the effect of the alleged conspiracy (except for one 12-month period).

[207] Singer Merits Report Backup; Singer Merits Report, ¶ 51 (p. 37).

June 30, 2014).[208]

101. Exhibit 6 illustrates this point. The "Conduct" variable (top bar) in Dr. Singer's model is unchanged (*i.e.,* always takes a value of 1) from December 1, 2007 to December 31, 2013, and also unchanged (*i.e.,* always takes value of 0) from December 31, 2013 to December 31, 2015. Dr. Singer's analysis included time controls for each 12-month period running from June through July, represented by the dark grey bars in Exhibit 6, and referred to as "time-period fixed effects." Critically, Dr. Singer's regression can only estimate the coefficient on the "Conduct" variable when it changes *within* the span of a time-period fixed effect.[209] This is because Dr Singer purported to identify the alleged conduct solely as a time period, but also controlled for changes over time directly; as I describe above, his analysis cannot distinguish between the two unless there is some span of time in which one changes but the other does not (*i.e.*, in which the alleged conduct stops while a year fixed effect remains constant).[210] This

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[208] *See* Kleidon Report, ¶ 134. Dr. Kleidon estimated Dr. Singer's model and confirmed numerically that Dr. Singer's "conduct" variable only identifies the average difference in implied EBS spreads between the last six months of the Class Period and the first six months of the Clean Period.

[209] Alternatively, the "conduct" variable could stay constant while a year control changes, although this is never the case in Dr. Singer's analysis.

[210] As an example, suppose that an economist is interested in estimating the change in German gas prices after Germany adopted the Euro on January 1, 2002. Suppose that in order to estimate the potential change in prices, the economist runs a regression analysis of daily gas prices in Germany between July 1, 1997, and June 30, 2006 and estimates a model that includes: (1) year fixed effects spanning all consecutive periods going from July 1 to June 30 (*i.e.*, 9 year fixed effects), and (2) a binary variable (call it "Euro time") that only varies over time and is equal to 1 on and after January 1, 2002, and zero otherwise. Since the Euro was not in circulation prior to July 1, 2001, the variable "Euro time" would be constant (and equal to 0) during the four-year period July 1, 1997 – June 30, 2001, and the variation in prices over time during that specific period will be entirely captured by year fixed effects. Similarly, after June 30, 2002, the variable "Euro time" is always constant (and equal to 1) and therefore any variation over time during the four-year period July 1, 2002 – June 30, 2006 will be captured by the year fixed effects. During the one-year period from July 1, 2001 – June 30, 2002, all the year fixed effects are constant (the relevant year fixed effect for July 1, 2001 – June 30, 2002 is always equal to 1, while all the others are always equal to 0), and the "Euro time" variable will

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occurred in precisely one 12-month timeframe: between July 1, 2013 and June 30, 2014 (when the "Conduct" variable changes from one to zero – from dark to light green). In the rest of the period Dr. Singer analyzed in his regression, the effect of "Conduct" *cannot be estimated* by Dr. Singer's analysis (represented by a red cross-hatch in Exhibit 6).[211] In the rest of the period, the Class Period is perfectly correlated with Dr. Singer's year fixed effects, so Dr. Singer's regression cannot estimate the effect of the "Conduct" variable.

102. The time-period fixed effects can be viewed as measuring "shifts over time in market conditions."[212] When estimating the effect of these shifts on average spreads for years in which the alleged conduct is assumed to be *always* in place or *never* in place, one cannot disentangle how much of the average spread in a given twelve-month period is determined by the "impact" of the conduct (or lack thereof) versus marketplace conditions in those years.[213]

103. Therefore, Dr. Singer's regression cannot be estimated in the manner he suggests

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capture *all of* the variation in prices within that period, in particular the price change between July 1, 2001 – December 31, 2001, and January 1, 2002 – June 30, 2002.

211 One clear implication of this observation is that, as long as the "conduct" variable used by Dr. Singer does not change before July 1, 2013, and after June 30, 2014, it is irrelevant whether it is equal to 0 or 1 during those periods, because those time frames will not contribute to the estimation of the difference in average spreads. In particular, the model estimated by Dr. Singer is equivalent to a model in which the conduct variable is equal to 0 (*i.e.*, denoting the absence of a conduct) before July 1, 2013, and equal to 1 (*i.e.*, denoting the existence of a conduct) after June 30, 2014.

212 Singer Merits Report, ¶ 54.

213 The only way to disentangle the impact of these two factors is to have one (or more) twelve-month periods in which spreads can be observed both before and after the end of the Class Period. Then the average spread during the twelve-month period will give the year-specific component (*i.e.*, shifts "in market conditions"), while the residual difference in average spreads between the portions of the twelve months before and after the end of the Class Period will identify the difference in spreads during and after the alleged conduct. Therefore, one can only separately identify the "impact" of these two components during the twelve-month period between July 1, 2013, and June 30, 2014. In this window, the "time-period fixed effect" stays constant but the Dr. Singer's "Conduct" indicator changes from being equal to 1 to being equal to 0 between December 31, 2013, and January 1, 2014.

to assess the causal impact of the alleged conspiracy on spreads. All he estimated was the average difference in EBS half-spreads between the last six months of the Class Period (July 1, 2013 – December 31, 2013) and the first six months of the Clean Period (January 1, 2014 – June 30, 2014). There is no reason to believe that the difference between these arbitrary periods represents the impact of the alleged conspiracy on implied EBS spreads (let alone customer spreads).

2. Dr. Singer Incorrectly Interprets the Results of his Regression

104. Even ignoring this fundamental problem with Dr. Singer's regression, Dr. Singer interpreted its results incorrectly. He failed to appropriately consider the differences between the EBS and customer segments, incorrectly interpreted his regression as identifying the causal effect of the alleged conspiracy on half-spreads, and ignored substantial heterogeneity between currency pair half-spreads in his results.

105. First, Dr. Singer cannot directly measure any alleged spread widening to customers because OTC spreads are unobservable.[214] Instead, Dr. Singer's analysis examined

[214] Singer Merits Rebuttal Report, ¶ 64. Dr. Singer acknowledged that "the spreads that dealers quoted to their customers are not observable."

only implied spreads on EBS.[215, 216] Therefore, Dr. Singer's analysis did not – and cannot – consider the appropriate segment of the marketplace.[217] Dr. Singer claimed that "[t]he FX prices posted on electronic interbank platforms such as EBS – that is, prices in the interbank segment – play the role of wholesale prices," and that because the alleged conspiracy in the customer segment increased adverse-selection risk among dealers, it also widened spreads in the interdealer segment.[218] Under Dr. Singer's theory, dealers source liquidity in the "wholesale" EBS segment and provide it to customers in the "retail" customer segment. That is, according to Dr. Singer, the EBS segment is upstream from the customer segment.[219] Therefore, any alleged

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[215] Dr. Singer ran a cointegration analysis to support his claim that "interbank prices are highly predictive of class member prices." *See* Singer Merits Report, ¶¶ 57-64. Based on this analysis, Dr. Singer concluded that "the Challenged Conduct is statistically associated with a decrease in market performance for the OTC Class." Singer Merits Report, ¶ 57. In other words, Dr. Singer's cointegration analysis assumed that his regression is correct and allegedly demonstrated that wider implied EBS spreads should also widen at-issue OTC trades. As I explain in this section, because Dr. Singer's regression analysis is flawed and incorrectly interpreted, his cointegration analysis relied on an incorrect premise. I understand that Dr. Kleidon contends that Dr. Singer's cointegration analysis did not establish the transmission of the alleged spread widening from the dealer-to-customer segment to the EBS interdealer segment. *See* Kleidon Report, Section VIII.B.

[216] Singer Merits Report, ¶ 51 (p. 37).

[217] Notably, Mr. Poynder explains that "in all but the rarest of cases, *the displayed price on EBS is not a quoted spread at all and certainly not to dealer bank customers*, but rather is simply the difference between an independent bid and offer made by different participants on an *interdealer* platform." *See* Poynder Reply Chats Report, ¶ 11.

[218] Singer Merits Report, ¶¶ 16, 50 (p. 34).

[219] Dr. Singer claims that there is a tight link between the interdealer and the dealer-to-customer segments. He supports this claim by stating that "the [alleged conduct in the customer marketplace] causes wider bid-ask spreads in the interbank segment because it increases adverse-selection risk." *See* Singer Merits Report, ¶ 50 (p. 34). As I explain, Dr. Singer has not provided evidence to support the existence of a conspiracy to widen all spreads in the dealer-to-customer segment. Moreover, while the transmission mechanism of adverse selection in the interdealer segment is outside the scope of my report, I understand that Dr. Kleidon has criticized this mechanism and has shown that Dr. Singer has not proven that adverse selection caused interdealer spreads to increase. *See* Kleidon Report, ¶¶ 57-67.

conspiracy that widened EBS spreads would increase dealers' "input" costs.[220] Under Dr. Singer's "wholesale" theory of the EBS segment, increasing the "input" costs of EBS transactions to dealers might have a negative impact on the Defendant banks' profits, and therefore could make any alleged conspiracy less likely.

106. Moreover, the spread Dr. Singer calculated based on the best bid and ask on EBS is different and not representative of the spread a dealer might quote to a customer in the dealer-to-customer segment. The implied EBS spreads Dr. Singer calculated reflect the difference between the current best bid and current best ask price on EBS.[221] I understand that the best bid price is the highest bid price sitting in the EBS order book at a certain point in time, placed by a party seeking to buy a specified volume of currency. I understand that the best ask price is the lowest ask price sitting in the EBS order book at a certain point in time, placed by a party seeking to sell a separately specified volume of currency.[222] The best bid and offer ask may not be placed by the same party (indeed, they very likely are not).[223] These best bid-ask spreads do not represent a single dealer's quotes for a particular size trade to an individual customer like in the dealer-to-customer segment, but rather are two quotes from different parties.[224]

107. Plaintiffs' experts Mr. Poynder and Mr. Robin agreed that implied spreads on EBS are not the same as customer spreads. For example, Mr. Poynder stated, "in all but the rarest

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[220] Participants on EBS and Reuters do not know the identity of their counterparty until *after* a trade is executed, and therefore, Defendant banks would be unable to discriminate in the spreads they quote to Defendant banks versus non-Defendants. Melvin Report, ¶ 26.

[221] Singer Merits Report, ¶ 50 (pp. 36-37).

[222] Kleidon Report, footnote 30; Melvin Report, ¶ 26.

[223] Kleidon Report, footnote 30.

[224] Kleidon Report, footnote 30.

of cases, *the displayed price on EBS is not a quoted spread at all and certainly not to dealer bank customers*, but rather is simply the difference between an independent bid and offer made by different participants on an *interdealer* platform."[225] Mr. Robin stated, "EBS spreads in the interdealer market also differ in other important ways from customer spreads, apart from the fact that EBS top of the book spreads reflect quotes from different banks whereas customer spreads are based on quotes from a single bank. The EBS spreads also often relate to much smaller trade sizes compared to the customer segment."[226] Dr. Melvin agreed with Plaintiffs' experts in this regard and notes that "spreads on EBS reflect liquidity conditions," but that "there are numerous other idiosyncratic factors that also affect the spreads that a dealer quotes to any particular customer at a particular point in time."[227] Dr. Singer's use of these wholly different spread measures in the "wholesale" EBS segment as a basis for calculating the impact of the alleged conspiracy in the customer segment is inappropriate and unreliable. Dr. Singer considered the wrong segment and failed to explain why widening spreads in the allegedly "upstream" EBS segment is economically rational.

108. Second, contrary to Dr. Singer's claim, his regression does not establish that the alleged conspiracy *caused* half-spreads to widen because he failed to control for other factors which may impact spreads. Dr. Singer claimed that his regression indicates that "holding other factors constant, the [alleged conspiracy] widened bid-ask spreads on average to the OTC during

[225] Poynder Reply Report, ¶ 11.

[226] Reply Expert Report of Eric Robin, August 13, 2020, ¶ 32.

[227] Melvin Report, ¶ 68, footnote 76.

the Class Period."[228] Specifically, Dr. Singer included separate controls for each year and for the Class Period as a whole in his regression.[229] If any characteristics of the FX marketplace affected EBS half-spreads and occurred at the same time as the Class Period, Dr. Singer's regression would assign the impact of these characteristics to the alleged conspiracy. For example, if there were any seasonal effects in the FX marketplace between June 2013 and July 2014, Dr. Singer's regression would ascribe their impact on spreads to the alleged conspiracy. Dr. Singer claimed that he "control[s] for *all* other factors that may have influenced the EBS spread."[230] However, Dr. Singer *cannot* (and does not) control for all other factors. As the textbook cited by Dr. Singer emphasizes, "[s]imply finding an association between two or more variables might be suggestive, but unless causality can be established, it is rarely compelling. [] In most serious applications, the number of factors that can affect the variable of interest…is immense."[231]

109. Importantly, Dr. Singer's model explained less than 40 percent of the variation in implied EBS spreads.[232] This indicates that Dr. Singer did not control for a number of factors which would help explain the remaining 60 percent of the variation in EBS half-spreads. Dr. Singer's regression cannot account for any such omitted factors that change between the end

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228 Singer Merits Report, ¶ 65. Dr. Singer also claims that "the EBS ask price would have been approximately 0.0041 percent lower in the absence of the Challenged Conduct," and the bid price higher (Singer Merits Report, ¶ 55).

229 Singer Merits Report, ¶¶ 51 (p. 37), 54.

230 Singer Merits Report, ¶ 51 (p. 37). Emphasis added.

231 Wooldridge, p. 12. This textbook emphasizes the need to conduct "an appropriate experiment" to identify any causal effect (Wooldridge, p. 12). Dr. Singer does not (and cannot) carry out any such experiment. Simply identifying the end of the Class Period is not an experiment, as it fails to control for other potentially confounding variables that may influence the EBS spread.

232 Singer Merits Report, ¶ 55. Specifically, Dr. Singer's model "explains approximately 38 percent of the variation in the log half spread over and above that which could be predicted with knowledge of the mean log half spread alone."

of the Class Period and the beginning of the Clean Period, so his analysis will not estimate the impact of the alleged conspiracy. In other words, the variable of interest in Dr. Singer's model can only measure the difference in average half-spreads before and after the end of the Class Period and cannot reliably disentangle which portion of this difference is due to the alleged conduct as opposed to changes in the FX marketplace that are unrelated to the alleged conduct (*e.g.*, secular changes in volatility and liquidity in the marketplace, new entrants, new technology, etc.).

110. Third, Dr. Singer's own regression indicates that the alleged conspiracy had no statistically significant impact on spreads for many currency pairs. Dr. Singer claims that his regression indicates that "*the* EBS spread narrowed after the end of the conduct period."[233] This refers to an average spread: there is no single EBS spread, but rather many spreads which differ by currency pair.[234] Dr. Singer's regression masks substantial heterogeneity in currency half-spreads by focusing on average spreads across currency pairs. In his Rebuttal Report, Dr. Singer estimated a model that only finds a positive and significant coefficient on his "conduct" variable for 21 currency pairs.[235] This suggests that for 60 percent of currency pairs (31 of 52 currency pairs), Dr. Singer's model showed that half-spreads either widened after the Class Period (for 23 out of 52, or 44 percent) or were not significantly affected by the alleged conspiracy (for 2 out of 52, or 4 percent), or Dr. Singer did not estimate a coefficient (for 6 out of 52, or 12 percent).[236]

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[233] Singer Merits Report, ¶ 55. Emphasis added.

[234] *See* Melvin Report, ¶¶ 95-98.

[235] Singer Merits Rebuttal Report, ¶ 57. Note that this analysis conducted by Dr. Singer in his Rebuttal Report includes implied volatility as an additional control variable.

[236] Singer Merits Rebuttal Report, Table A3.

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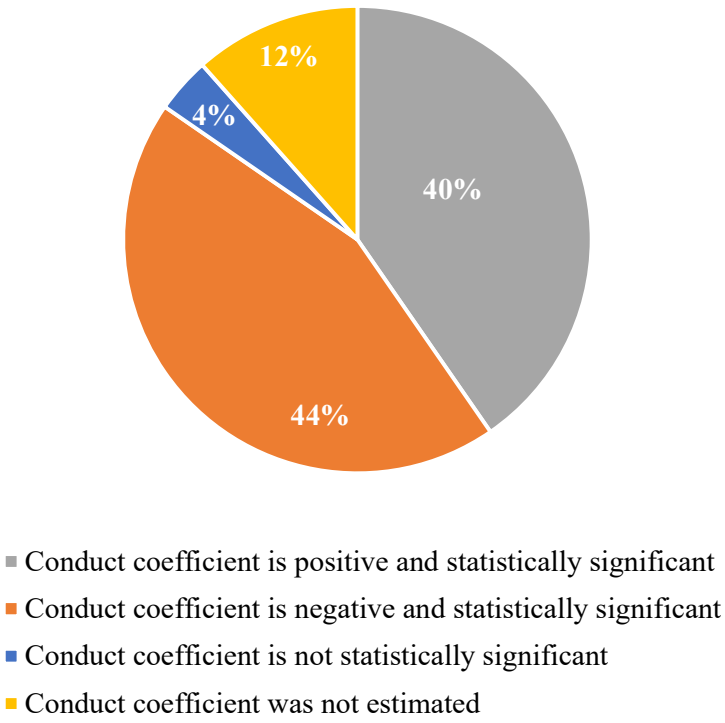
Therefore, Dr. Singer's disaggregated results show that there is significant variation in his estimates of allegedly collusive spread widening across currency pairs, including many currency pairs for which his model found no spread widening at all. This is at odds with the allegation of a marketplace-wide conspiracy involving 52 currencies. Dr. Singer made no attempt to explain why any alleged collusion would narrow spreads in some currency pairs but not others.

Figure 2. Shares of currency pairs by Conduct coefficient estimate in Dr. Singer's Rebuttal Report



Source: Singer Merits Rebuttal Report, ¶ 57, and Table A3.

111. Fourth, Dr. Singer's regression analysis ignores heterogeneity over time. Even if Dr. Singer's regression could identify the impact of the alleged conspiracy (and it cannot), his single reported estimate would capture the effect of *all* years from 2007 through 2013. In other

words, Dr. Singer's reported "conduct" variable obscures all heterogeneity in the effect of the alleged conspiracy over time even though there is significant variation in spreads over time.[237] Indeed, even if Dr. Singer's regression were able to measure the impact of the alleged conduct (and it cannot), Dr. Singer's own analysis in response to Dr. Kleidon indicated that the impact of the alleged conduct varied significantly over the Class Period.[238] For example, when comparing the 13 six-month periods during the Class Period to the first six months of the Clean Period, Dr. Singer's own analysis showed that spreads were wider *after* the end of the Class Period in 2 of the 13 six-month periods.[239] By Dr. Singer's logic, wider spreads after the Class Period implies that the alleged conspiracy *narrowed* spreads.

C. Outcomes in the FX Marketplace Are Inconsistent with The Existence of a Conspiracy to Widen All Spreads

112. A conspiracy to widen all spreads in the FX marketplace would be expected as a matter of economics to yield certain outcomes in the marketplace. While Dr. Singer agreed that it is crucial to evaluate these outcomes, he failed to properly evaluate several key economic indicia of the "performance" of an alleged conspiracy. First, a conspiracy to widen spreads would be expected to reduce the volume traded in the marketplace relative to the volume that would have been traded in a competitive marketplace. Second, one would expect to observe stable shares among conspirators.

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[237] *See, e.g.*, Melvin Report, Exhibits 4A-4E.

[238] Singer Merits Rebuttal Report, ¶ 44.

[239] Singer Merits Rebuttal Report, ¶ 44, Table 3A (top row).